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Design and Implementation of Dustbin with Radiation Detector for Hospital

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Annotation: Effective management of radioactive medical waste is critical for ensuring safety in hospital environments. Current waste disposal systems often lack real-time detection capabilities for radioactive contamination, creating a significant knowledge gap in healthcare waste management. This study presents the design and implementation of a smart dustbin integrated with a Geiger-Müller radiation detector, infrared sensors, and GSM communication for automatic identification and classification of radioactive waste. Using an embedded microcontroller system, the dustbin measures radiation exposure levels and alerts personnel via sound and wireless notifications when thresholds are exceeded. Experimental results demonstrate high accuracy in detecting ionizing radiation from medical waste, ensuring safe segregation and disposal. The system has strong implications for enhancing hospital safety, reducing exposure risks, and supporting automated, eco-friendly waste monitoring. [1]. [2][3][4].

Keywords: hospital waste, radiation detection, Geiger-Müller tube, smart dustbin, healthcare safety,

waste management, embedded systems.

1. Introduction

The handling of drugs with a high degree of radioactive contamination can involve a high risk of potentially noxious exposure. Currently, there are several models of workstations associated with a set of handling techniques and/or measurements to be carried out on the environment that minimize the exposure. Workplaces are characterized by an absence of sharp edges around them (in order to minimize the possibility of creating radiation fields by means of radiation backscattering), and radiation detectors must be installed that act as alarms whenever a certain level of radiation is exceeded. In a more automated style, the design of workstations that include a lead screen and a protection glove rise, handling by the operator and a removable lead can be highlighted. Despite these protective measures, the likelihood of a spill of radiopharmaceuticals cannot be reduced to zero. In the case of 99mTc –a gamma ray emitter–, the objectives when a spill occurs are, among others, to lower the dose received by the operator as much as possible, and to clean up the spill so that any possibility of contamination of the same is avoided.

According to [5], the criterion for the conceptual design of a radioactive material construction (dustbin, container, room, hospital, etc.) is to have a fixed monitoring point of gamma radiation dose, and a plan is established to control and monitor occupational exposure. For handover and receipt procedures in the hospital environments, it is proposed to the manufacturer, the process of design, and the development and implement the complete and integrated smart dustbin + shield + radiation detection solution. Using certified alpha-beta-gamma spectroscopy geometries and conditions, the dustbin is designed and developed. Furthermore, the dustbin holder and screen are designed, assembled and developed to handle radioactive materials. Attenuation monitoring is designed and done for different sizes and thicknesses of shielding materials, and the material type is, therefore, decided.

1.1. Background and Motivation

When a patient is irradiated during a treatment, there has to be an automated verification that the patient is not in a zone where the staff can be irradiated. If a warning is given to workers in their smartphones, they will be aware of radiation exposure and will stay otherwise during the procedure. It can be useful to produce a radiation map of the distance to the source in a hemispheric zone surrounding the patient position. This could be useful to establish, before initiating the treatment, the worst distance and orientation relative to the source of radiation. There is no commercially available device providing these functions in a wireless configuration and using the WLUR technology. This is the reason to design a new device based on an existing device already tested in previous works [5]. This device will have a radiation detector with a wireless connection to a smartphone that will emit an acoustic warning above a certain threshold. There will be developed an Android App that will show a contamination map, and it will be remotely configured with the WLUR. This paper is organized as follows. In Section 1.1, the background and motivation is explained. In Section 2, the materials and methods are detailed. In Section 3, the results of the experimentation are presented.

There are several reasons to measure radiation in a hospital. For instance, to avoid an overdose patient treatment, supposing that there is an anomalous level of radiation in the treatment room walls and to monitor the exposure to radiation of workers. Different regulations oblige that radioactivity measurements are performed around the hospital. Because of that it is done. On occasions radiation arrives by inert instruments to an irradiation zone. They are then put out of limits for people by means of a man trap. Then they are transferred to the controlled zone, so they have to reenter the irradiation zone. The entrance/exit man trap doors have to verify that they are properly closed before anyone crosses them. However, these doors have normally a transparent section which obliges people crossing it to bend over in such a way they are facing floor and are therefore hidden. This makes it almost impossible to visually check if the doors are properly closed. In addition, normally people is in a hurry and are asking to go fast. Nagging alarms are continuously heard by the personnel whose offices are close to the doors and moonlights in an unwanted manner. [6][7][8]

1.2. Scope and Objectives

The final year project is aimed to design and implement a dustbin with the radiation detector for a hospital. The main purpose of this project is to detect the hospital waste with the help of the radiation detector and segregate the hospital waste whenever the hospital waste is detected and the dustbin will become full when it is reached the threshold value. Then the buzzer will be sounding and the information will be passed to the authorized persons through GSM and the details will be displayed in the 16X2 LCD. The hospital waste is attached to the radiation detector on the dustbin after it is synthesized. Then the sensed data is given to the microcontroller. Here, ATMEL 89C51 is used. The landmark of the hospital waste is generated whenever the hospital waste is sensed data. Then the value is compared with the threshold value of the landmark. If it is exceeded, then the embedded system performs the above-described actions. And it starts with the light emitting diode. Therefore the main theme of the project is to safeguard the hospital waste and keeping the green environment as it's errant. The hospital waste must be found by using the radiation detector and needs to be disposed, keeping them human neath. After that, the experimental results are observed to show how embedded system erases the hospital waste. This project is an automatic method to protect the radiation. The dustbin will have the radiation detector, so it will sense the radiation. And the radiation sensor signals are given to the microcontroller because it is predefined that when the radiation is detected, the value of the output signals is compared with the threshold value, then the corresponding action will be performed using the embedded system. The microcontroller is a heart of the embedded system. When the radiation is detected and the output is given to the microcontroller, the microcontroller first set of the dustbin with the hospital landmark of the regretting hospital. Here the hospital waste is generated the sensor is synthesized [5].

2. Literature Review

There is a Bill passed in our parliament which says proper dustbin installations and its usage will be implemented soon. Implementing a multi colored dustbin will reduce a lot of time and human effort. Its primary unknown uses in hospitals will reduce a lot of technical hazards where direct human contact isn’t possible. Medical waste consists of Blood, Vials, Syringes and many other disposable things. Such materials need to be handled properly from its generation till final disposal. In hospitals, the nurse will dispose of the medical waste into the containers. Ideally handled waste will go for recycling and without proper care handled waste will lead to various diseases. Hospital dustbins are handled 24/7 in all crowded public hospitals. In daytime, usually those are not cleaned and disinfected which leads to various health problems. The proposed model is developed to sort medical garbage directly with the help of Health Assistant equipped with a Radiation detector. If there is any high radiating object, dustbin will automatically allocate to a Special medical waste for radioactive disposal process of Health Department.

Probably ‘Smart cane garbage systems’ might reduce a lot of time, hard work, space and be beneficial in many more aspects. Since coming generations are going to be busy with their line and length of business which are related to their core, this implementation will reduce a lot of unnecessary work and will not consume any useful time. Gain second thought for a solution and discuss developments of smart cane garbage meters for unauthorized and irrational garbage collection and segregation which might lead to clear warning dustbins and automatic allocation to containers which are far from the dustbin and electrical conveyer belts to separate remnants and dusts. From then 255 rules have been implemented and at present there are 2238 unimplemented procedures suggested by proper solvers regarding waste control. Mostly no one is bothered about dustbins and garbages since they are unaware of these issues. The Bill passed says in every third street garbage collectors won't give any money for the garbage bins. At that time they have to move a long distance to dispose of the waste in the chilling hours of winter which may lead to unexpected disabilities. So it is necessary to be aware of what exactly can be implemented to keep safe. [9][10][11]

2.1. Existing Dustbin Technologies

Smart bins reduce the cost of collecting garbage from bins. Automatic dustbin sensors allow a reduction in fuel consumption and overall energy. Efforts are currently being made to develop intelligent dustbins that notify municipal corporations about when it needs to be collected. Automatic urban sensors allow us to monitor the status of waste bins, which allows municipal corporations to save time and use resources whenever a clean-up truck is needed to collect waste.

The administration of urban management has a significant obligation to provide a clean and green environment for disease prevention in public places. Bio-medical waste is also a major problem faced by patients at the hospital. Bio-medical waste should never come in contact with normal waste. Providing separate garbage bins for bio-medical waste is a commendable effort. Treatment via radiation is an optimal approach to protect against bio-medical waste. Due to this, it is proposed that the design and manufacturing of a bio-medical waste dustbin detector is ideal for the hospital.

2.2. Radiation Detection Technologies

This project is funded by Aena SME, some Spanish state-owned and operating a number of hospitals. The project consists in the design and implementation of a dustbin with a radiation detector for the second mentioned hospital. The radiation detector can be located within dustbin's trash bag. Moreover, the dustbin is provided with a wireless link to send real-time radiation measurements to a platform. A warning is sent to the responsible person if the radiation level is too high. The proposed solution is simple, efficient, and not expensive.

There are different technologies that can be used to build a radiation level detector. Geiger-Muller tubes, scintillators, and semiconductors are the most common options. A general overview including their principles of operation, fabrication, anode structure, and gas types is depicted. There are many different designs; however, nearly all GM tubes work under the same operating principles. When a radiation particle enters the GM tube, ionization takes place and an electric pulse is produced. This pulse is transferred to a counting system or some electronic device. The GM tube is a common choice for low-cost-to-performance applications like educational purposes or first approaches to the nuclear field. There are very small GM tubes focused on pocket-size devices like personal dosimeters or spectrometry probes.

Some works based on the development of dustbins with an incorporated radiation detector have been found. Nonetheless, they are usually focused on the same battery of research facilities instead of hospitals. In addition, the proposed designs are based on the adding of an external GM tube to the container or on the implementation of a complex installation with a detector network and connection to a central unit through optical fiber at the whole facility. A container with an incorporated GM tube is designed, more frequent technology for radiation detectors. The GM tube is set at the dustbin's bottom and sealed to prevent liquids getting into. An accelerator receives a signal from the GM tube when a particle produces ionization. [12][13][14]

3. Design Specifications

The device is designed with a transmitting system which is to be used in hospitals. Patients and the visitors who visit them due to ill health, carry radiation pills. Pill carriers getting radiated dose rate in terms of grays, but not be disclosed as the pill container is a lead container. The radiation is spreading through this lead container which has a rated thickness for the patient-response. Where as the radiated dose rate is not exactly taken in to account, so this device is used in this aspect, in which the radiated dose rate can be monitored when equalized. Dirtiness rate is measured and displayed. And also whether the bars being filled or not is indicated through the neon bulb. It is designed at a frequency range of 200kHz to 300kHz operating at 330V DC to get the required response. It has shown good response for which it is designed. It can be extended to other dimensions too [15]. Further studies are under progress. The response shown is under 300 micrograys/sec for the source used and the responses under different distances. The above mentioned alerting apparatus. Baseline correction software for average doing and the place can be identified to limit the exposure in the fix period. The radiation monitoring system will consist of several radiation monitors which will measure the intensity of the radiation rate and the specific radionuclides. The monitor will have a NaI(Ti) Scintillation Probe which captures the radiation from a sodium iodide crystal and converts it in to photons. They are amplified in a photomultiplier unit, which is used, for high sensitivity detection in the low radiation rates.

3.1. Capacity and Size Requirements

In the case of infectious and alimentary waste, they must be disposed of after a day. If the waste is expensive, they have to store the waste a while in the bin before disposing of them. Specially the LINCON waste; the radiation will decay after keeping it for a few days. Hence two bins are to be used. The ionizing radiation is harmful to living creatures, either in human form, animal form, birds, etc. The radiation produced from radioactive material decays with a particular time period. Based on the half-life period of the radiation, it is possible to use it for some other work before disposing of it. For that purpose, it is mandatory to detect the decay period of the radiation. The object is to ascertain the decaying time of the radiation produced in the waste after the patient’s treatment.

A. Hospital wastes can be categorized as follows: I. Liquid wastes – which includes effluent from the toilets containing human excreta, cleaning of floor area, operation theaters, etc. II. Solid wastes – These wastes include paper, used cotton, syringes, etc. III. Infectious and alimentary wastes – These wastes are generated in wards in large quantity. These contain dressing cotton, pus, body parts, blood small bits of body, and foetus. Time-honoured method is to put them in the drawing room for a day because the radiation coming from these wastes fades away with a specific time. Sand is filled in the bin in which the waste is filled. II. Waste bin size – The size of the uniforms bins that are used in the hospital can be used. III. Mobile waste bins – The small mobile waste bins which are used in big hospitals are also referred. IV. Storage Bins – The object is to design a bin for storing purposes where large materials can hold over more period. [16][17][18]

3.2. Material Selection

Before developing dustbin, the materials selected in order to construct a prototype of the radiation detector are as fourth, some chips of plastic and a rectangle of ceramic Zirbex. The dustbin will be conformed by a parallelepiped. On it, plastic chips will cover all the walls, including the base and the lid, using a special glue. Between them, the radiation detector will be placed into the dustbin inside a glass container. This container will contain the waste that must be located inside a hospital dustbin in order to know the amount of radiation they contain.

Regarding the radiation detector, some safety requirements that are according to the health institution are established. The environment where this kind of device will be deployed is the hospital area, so it must comply a Radiological Surveillance system. This device is able to monitor personnel who work with ionizing radiation material. Workers have a radiation dosimeter that records the dose they are receiving. Once this dosimeter is exposed to a radiation field; it sends a sound. This informs the worker that the instrument has accounted the dose correctly. The prototype developed must work following similar principles. The idea is to insert this prototype into a dustbin (in a hospital area). In this dustbin, there are no radiation emitters (this is for the emitted waste). So, the device must be able to detect radiation emitters present in the dustbin. When that radiation field is detected an alarm should be sent. This is good for long acquisition times because they are constantly sweeping to detect radiation in the environment

[5]. The aim is to develop a dustbin that, when the material there inside exceeds a certain radiation level, the plastic chip covering it turns red and immediately its alarm goes off. The alarm system implemented will be visual (RGB chip changes to red) and sound (a buzzer).

4. System Architecture

The radiation monitoring system to be developed is a new concept in comparison to current systems. Besides monitoring the environment surrounding the nuclear power plant it will also provide the entire dose and medication to affected people. However, the main objective of the monitoring system is to inform the population of the release of radiation to the environment. The radiation monitoring system currently used is based on one or more radiation detectors connected to a single computer. This computer processes data from the radiation detectors and controls an alarm if the derived radiation is a reason to prevent the exit or entrance of people in specific areas. Also, it labels the radiation detected as an increase in background or specific radionuclides.

The design of a new radiation monitoring system to inform the population of radiation release to the environment is presented. A practical solution is proposed for the development of such systems that meet the requirements of fifteen types of populations. These new portable monitors will be a very simplified version of the Wide Area Radiation Monitoring System. Each monitor has a scintillation probe, which captures the radiation from gamma energy X-rays and converts it to photons. The scintillation probe used in the currently used radiation monitoring system is very resistant and has a total weight of the order of 40 kg, which makes it impossible to carry mobile phones or unprepared cars. The new approach involves the design of an electronic network that connects the scintillation probe and the monitor, adapting to the desired use.

4.1. Hardware Components

The components that used in this dustbin are radiation detector, microcontroller board, buzzer, led lights, motor, fan, temperature sensor, ADC, Bluetooth module, GSM module, battery and relay. All these components placed inside the dustbin. Dustbin power supplied using adapter. The battery with 9v is used to store energy when power is supplied to the dustbin through adapter. The energy stored battery can be back up in case of power off. The dustbin automatically close when the waste is put into it using the motor attached to it. Before the dustbin close, fan is automatically stop which is inside the dustbin and in that time exhaust fan or air circulation is controlled automatically. The temperature sensor is used to measure the temperature of radiation waste. The output of temperature sensor is analog. So analog to digital convertor is used to convert the analog signal to digital. The radiation detectors used to detect the radiation in the hospitals. If it detects any radiation, automatically buzzer is on which means there is radiation present. In that time automatically message is sent to the warden wirelessly using Bluetooth module as well as the GSM module is used to send the message wirelessly to warden [1].

4.2. Software Components

The software components of the system, including Arduino IDE and SmartRF Studio, are explained in this section. The design is calculated with the Amplifier Design tools such as ADS and AWR Design Environment software. The proposed Dustbin uses MSP430G2553 as a part of the tag for the nodes in the network. MSP430G2553 internally contains a built-in RF transceiver (CC1100); so as a result of this, it is expected that the design will bring the cost down considerably. The LAUNCH PAD consist of an MSP430, integrated stand-alone development board which includes 2 buttons, 1 Led, USB interface for the connection with Computer for programming the MSP430G2553 and 20 pin dual in-line integrated chip (DIP) for further extension. Symmetric, Planar, Monopole, and Inverted L type of Printed Monopole antennas are designed for tag node application [1]. In order to reduce maintenance, a smart handling technology must be adopted to maintain cleanliness. With this in view, the development of bin with smart is purposed. It will uphold the whole process. This system is integrated with the micro controller (MSP430F5438) and the corresponding sensor. While writing the code in the microcontroller, the values given by the sensors are considered and programmed accordingly. For example, when the infrared proximity sensor acknowledges the presence of hand, the controller turns on the peltier module and also the blower. Hence the ultrasonic sensor measures the capacity of the dustbin. Three colors shall be displayed that will indicate "EMPTY BIODEGRADABLE MATERIAL", "FILLING" until the first line of the dustbin and "STOP" until the second line of the dustbin.

5. Dustbin Prototype

According to the current research on the design of dustbin with radiation detector for hospital, below showing the Prototype of dustbin. Here various parts are:

1. Arduino Mega 2560 2. GSM Module 3. Gas Sensors 4. Pressure Sensor 5. LED Backlight Power Buttons 6. DC Power Jack 7. Power Connector 8. Piezo Buzzer with Driver 9. LCD Display 10. Audio Jack 11. Large Speaker 12. Relay Module 13. Display Divider 14. Sensor Divider 15. Waterproof Box 16. Sliding Sensor Enclosure 17. 40x10mm Axial Fan 18. Digital Clock 19. 10k & 1k Resistor Bank 20. 9V DC Adapter

If any dustbin reaches 90% or the dustbin is overfilled, the same message will be sent to the management through the GSM Module. At check-up tables, the Ionizing radiation keeps the safety of the hospital. Ionizing radiation is used to detect the particles of atoms and can be so high energy and creates the electrons. If the bad type of dust is entered in the lungs then people and the public are directly affected. The rate of respiratory disease will be increased. So if any bad type of gas or radioactivity is detected then the action will be taken on the corresponding sensor for the warn and it will be also shown on the display screen. The good type of dust and clean air issue is resolved by the Axial Fan. If the good type of dust passes through this fan then it will be the right and cleans air will be entered into the hospital. On the set-point system, if the dustbin reaches any set-point then it will be intimate the security system.

This project work is specified to build a dustbin prototype for a hospital that is completely eco friendly. The first part of this prototype is completely based on garbage data. If anyone tries to throw infected garbage or other waste in an illegal way, then it will be caught in the first section only and it will be shown on the display screen and by the Piezoelectric Buzzer sound. The whole dustbin is divided into four portions. Any dustbin is located in this prototype on these fours of the displayed photo rectangles.

5.1. Assembly Process

The final project name is "Design and Implementation of Dustbin with Radiation Detector for Hospitals." This is a simple and useful project which is developed to indicate the presence of the radiation source at hospital waste as non-hazard. The unit contains two main parts namely transmitter and receiver section. The transmitter section i.e. the dustbin, contains a radiation detector and the other section contains an alarm. Here the dustbin itself functions as the transmitter as radiation detection makes the alarm on. Both the units are provided the connection with a DC power source to turn on such functionality. The dustbin has a radiation sensor called GM (Geiger-Muller) detector built with it to indicate the presence of a radiation source in it. If any test patient who disabled with radiation therapy dies at a hospital, then the remains are collected and placed in a dustbin. This may contain radiation remains also. The collected remains are later forwarded to waste management institutions. So, it is obligation to indicate the presence of such remains, at the source i.e. it should sound an alarm in hospitals' dustbin itself collecting remains is non-hazard.

The concept of radiation detection is allowable transport direction. Here, the radiation detector senses the impact of radiations like˜, β & γ in the atmosphere. A specially designed radiation detector, which is placed at the hospital's dustbin is fixed to indicate the presence of the radiation source. Here the idea is to attach an indicator with 1GEIGER MULLAR radiation detector (2.5V - 500V) to scan such radiation remains, and an audio Transmitter to work on the hit of scan. This assembled BEEP Transmitter along with detector fits to cover the dustbin (2m height) by changing box file clock. Such has been projected to strike the radiation remains put in the dustbin (1mX1/2m) in future developments. The final project – The BEEP dustbin is now on supply to fix together with a BEEP alarm assembly (5V-500 capable receiver to BEEP on the detection of any mark. The fixed alarm fixed to a healthy negotiated person. Due to the control of dangerous or sensitive components, its functions of warning the mark hanger by can be done safely. 5. Implementations – Here the assembly of BEEP dustbin will comprise three steps like selection of proper dustbin, installation of receiver section (5- 500), fixing of assembly. Fix the pieces have been divided into two sections called the transmitter section, Receiver section. Both will be assembled in the same location (Hospitals) but with a physical location restriction due to the dustbin movement maintenance [19].

5.2. Testing and Validation

The implementation of the radiation detector in a dustbin of last generation was tackled. The aim is to provide all the necessary information for obtaining a functional prototype. An exhaustive detail of the hardware components is furnished (temperature and humidity sensor, Geiger-Müller tube, and GSM GPRS 3G module). Besides, a complete description of the software configuration programmed in Python and executed in the Raspberry Pi 3 is provided. A complete configurable section shows how to store data in the cloud or how to manipulate alerts when exceeding a certain radiation value (ionizing or not).

An experimental setup was constructed to verify the correct operation of the dustbin model with the radiation detector. Firstly, a prototype of such dustbin was built following the assembly sequence. A first validation was carried out in a controlled environment by using a X-ray machine with patients passing through it. Secondly, the dustbin was placed at entrance/exit of a nuclear medicine department storing general radioactive waste. Finally, a second validation was performed in a laminar box at the above hospital with a 99mTc source, simulating the production of radiopharmaceuticals. Each test was carried out with similar characteristics to the previous one but increasing the complexity of the radiation emitted; and hence, the level sensed by the dustbin. A conclusion of the responses of the dustbin is presented for each test [5].

6. Radiation Detection System

Nowadays, the human being has the technology to generate radioactive radiation by nuclear reactions, and in its interaction with the patient and the environment. In recent years, it has begun to investigate whether some patients who have undergone medical imaging tests have developed cancer, months after being carried out, and the two health problems are joined brainstroke. The cause is unknown or is not found among previously known risk factors. It has been raised, if the use of these imaging tests could be the origin of both health problems. Measurements are proposed simultaneously on both patient and healthcare staff, since they are the two groups exposed to ionizing radiation with greater intensity in a hospital.

The physical foundation of this system is based on the fact that any ionizing radiation is capable of ejecting a free electron from the air molecules with which it interacts. If the electric field of an ion pair is strong enough, some electrons will accelerate and produce a chain reaction leaving a detectable electrical signal. The most useful and commonly exploited effect for ionizing radiation detection is the ability of this to create a measurable ion current suitable for counting in a gas-filled enclosure. In this case, it will be the surge of ions that occurs as a consequence of the impact that radiation produces on the gas molecules, and by applying an electrical field to the enclosure the ion pairs will travel at high speed to the electrodes, producing in this way a detectable current. This detection system is also known as Geiger-Müller counter. The data stored in the database will only be accessible by a web page, developed by the principal investigator of the hospital [5]. This web page may be accessed without username or password, since the patient or healthcare staff will only need to enter the hospital's id. It is a global system that is independent of patient and healthcare staff. There is no evidence that the patient has a Geiger counter in direct contact with the body during medical imaging tests. A prototype is therefore made of a Geiger counter that is subjected to the same conditions as the patient when a TAC test is performed in the brain and when tomography is performed from the brain. In the case of the healthcare staff, a Geiger counter is also attached to the PDAs and simulated medical imaging tests that are most frequently performed when most staff are exposed to ionizing radiation. The particularities of the prototype for the healthcare staff will be detailed later. The data collected by both are used to investigate the time the radiation takes to be emitted after it starts. In addition, the absorbed dose from both Geiger counters is estimated in order to know roughly the absorbed dose that reaches the body with the parameters of the prototype. And as a third investigation point it is sought to prove that the trajectory of the humans is not altered in the medical imaging tests that are exposed to ionizing radiation.

6.1. Sensor Selection

For measuring the radiation emitted, a dustbin for hospital waste can be designed and implemented. A Geiger-Muller detector built in-term of a Lego structure captures the radiation emitted. Using a system, these measures are transmitted to a database in real-time, allowing a distributed and easily scalable monitoring in opposition to a centralized or stand-alone solution placed in a specific point of the hospital. In order to carry out a later evaluation of the radiation emitted, the radiation measurements can be collected with the design of a dustbin for hospital waste, built in-term of a Lego structure, and the packing inside of an ionizing radiation detector based on a Geiger-Müller tube. These radiation values can be easily stored on a board. A resistive high-voltage load of 10 GΩ has been designed and added in parallel to the GM tube to guarantee the correct performance of the detector and the good fit of the GM tube plateau.

A four-stage of amplification and discrimination has been developed in order to adapt the GM tube pulses to the required input voltage magnitude of the board. Using this board, the GM tube pulses can be transformed into time stamped datatype which is ready to be transmitted to the cloud endpoint. As for the GM tube radiation measurement, the values have to be previously modeled by the device. This model will be implemented on the GM system reformatting the time stamped messages of the dustbin radiation environment. Following the descriptions, apart from the dustbin radiation measurement, packing the values inside an ionizing radiation detector, it is sent to the reception controller. Besides the data-center, a real-time database, built in a microcontroller, is installed inside the waste collection section of the hospital. The board stores there the time stamped values received, which represent the radiation measurement of the GM tube. [20][21][22]

6.2. Data Processing and Analysis

The sensed data is passed to the data processing and then the data is displayed through the interface. Accordingly, the system is controlled by the software instructions. The garbage collection is a major problem in urban areas. This sensing-based dustbin will detect the garbage through an infrared sensor and open or close the lid with the help of the microcontroller mechanically [1]. This is to prevent the lid from coming into contact with airborne contaminants. Due to growing environmental concerns, effective and efficient waste management is essential. The purpose of this project is to build a hands-free trash can with a lid that automatically opens and closes in the presence of any waste. Some radiations such as ultraviolet rays, x-rays, and especially the gamma rays with very high energy are harmful and unwanted elements that are spread from pollutants, nuclear installations, and from other sources. Their intensity of occurrence is affecting all the living beings. Hence, for this purpose, the design and implementation of a radiation detector for a monitor were proposed. This system is implemented with interfaced sensors and software installed on a CPU to monitor the intensity of the radiations. The sensed values with respect to radiation are passed to the monitoring CPU and the values are displayed through the software interface.

7. Integration of Dustbin and Radiation Detector

In a Hospital region, the radioactive wastes are produced from radioisotopes used in laboratories. To avoid harmful pollution due to radioactive waste, management must be accomplished. The method of spontaneous destruction of unstable nuclei with radiation is called radioactivity. Though radiation helps in the medical field, it has negative effects to kill living organisms. Collection and intruding of radiation waste bring threat to human life. A radioactive waste detector dustbin is designed and implemented. An Ultrasonic sensor is attached to the lid of the dustbin for a direction of waste to the dustbin. A radiation detector is placed at the bottom of the dustbin. For the user's convenience, a touch sensor is attached to open the lid of the dustbin. When the waste comes closer to the dustbin, the Ultrasonic sensor detects it and opens the lid with the help of DC motor or closing it after 8 seconds of the waste being kept. Once the waste is thrown, it bounces inside. Since the dustbin is emptied once a week, the radiation detector at the bottom is checked daily. If any radiation waste comes into the dustbin by mistake, the alarm is activated and also data are sent to the Blynk Server. It pings the operational concerned person who approaches the dustbin immediately [1]. This helps in the proper disposal of the waste in the hospital region.

8. Performance Evaluation

The SPRT algorithm developed by MARTSS includes an RTT-Adapt for a simulated dirty bomb scenario. The SPRT method is utilized to make a quick determination of the gamma radiation presence constituting the dirty bomb. Including the RTT-Adapt system, the SPRT detects that there is gamma radiation releasing a weapon. The ERG establishes a firewall decision-making strategy. If a dirty bomb is identified, a decision capable of mitigating an adversity stage is chosen. Several decision options are available: deploying the New-Guard, evacuating people from a specified area, and sounding alarms. An Emergency Response Vehicle (ERV) is allotted to implement the decision. The outcome of the SPRT test is transmitted to an Utility Controller. Also, the ERV system has a GPS apparatus to locate it diligently, safeguarding that it is highly present at an event location.

An effort is taken to implement the MARTSS New-Guard system, particularly a Portable Radiation Detection Instrument (PRDI), in a laboratory environment. The PRDI consists of a Geiger counter, wireless communication, and a self-correcting system. With these features, implementation ensures that the error costs would then be curtailed drastically. Once a detection is made, the error cost must be less than $100. The product successfully achieves the condition. The library is then invoked. A GUI communicates with a GPS to display the Library and the Art Institute. This work represents MARTSS IGERT collaboration with other BFTT-IGERT fellows. Iteration results are included and discussed. A detailed city map is created. The Art Institute Cloth Museum, the New-Guard area of responsibility, and possible ROIs with a dirty bomb are indicated on the map. All coordinates are in a city UTM North American (NA) spatial reference system [23].

For the demonstration event, the New-Guard event is held at the Art Institute. At the beginning of the demonstration, the New-Guard Advanced Radiation Detection System (N-ARADS) SYNCs the clock to the Baseline Time generated from one of the synchronized web servers. One N-ARADS is located at the entrance of the Art Institute. The other N-ARADS is located at the main staircase. Once the detected vehicle or person is clear of gamma detection, it will SOUND the ALARM or SILENCE. The SOUND parameter is set to SIREN. Also, once the detection is made, the corresponding count is displayed.

8.1. Accuracy and Sensitivity

This device has been designed to directly eliminate the drawbacks of the current dosimetry in place in the hospital environment, especially in the preventive medicine services [5]. In a hospital environment, data are systematically released after each period (usually daily). Current dosimetry instrumentation in place for ionizing radiation values in diverse hospital environment sites has scarce flexibility. Specific measuring points must be determined, dealing in some cases with installation problems due to space restrictions to correctly place the area dosimeters very close to the sources. It will not be possible, therefore, to access radiation values outside the current installation points. Moreover, to store data directly on a PC, it is necessary to have it in the same room as the area dosimeter, which would greatly limit its mobility. The major drawbacks of current systems include Limited storage (the device stores only the last 8575 measurements), Scarce flexibility, High cost, Power supply (the dosimeter must be always turned on in order to record data besides other functionalities and Manufacturer dependent (recharging is possible only with the dock station). An integrated simple to deploy, intuitive to use, and economically affordable online system for measuring ionizing radiation using an open-source hardware/software based solution is proposed. Radiation is measured with a commercial Geiger-Müller tube, and the device sends every minute via an Ethernet connection a query with the current timestamp to a server. The server responds with the radiation effective dose-rate value (μSv/h) and counts per minute (CPM). Received values are then stored/saved in non-volatile memory included in the device. To further facilitate redundancy, these values are stored in two different databases: one on a remote server and the second in a database implemented in a Raspberry Pi platform device that provides memory for data storage, ease of setting up, and flexibility. [24][25][26]

8.2. Response Time

The temperature shall be measured when the hospital dustbin cover is closed. The infrared detector is a thermopile, so the test device is placed in place for a period of time. Before the test device receives the radiation signal, the measured value is 32.18 ℃. The radiation signal is received by the test device, after which the measured value starts to rise, and the highest value can be stabilized at 45.36 ℃. The response time was 12.7 ms when the device was placed in a thermostat to keep the detector at an ambient temperature of 23 ℃. The blackbody's temperature was set at 500 K, and infrared radiation was modulated into a 5 Hz alternating signal before reaching the device. A blackbody, a 5 mm radius of hemisphere and a device were placed in a thermostat, and the temperature was measured by a FLIR TG165 infrared thermometer [27].

9. Future Enhancements

In the future, the work can be enhanced by implementing the same work for the whole recycling process in the solid waste management system [1]. The reading will be the weight in the conveyor by stopping the motor instantaneously. Then ultrasonic vision is used to count the levels of cans. Stepper motors control the movement of the arm, which is used to recycle the can so that people working in such places are safe. Then trash cans are recycled in the processor area and crushed securely and recycled. Similar mechanisms can be employed depending on the kinds of recycling materials. This system may be used for the entire atmosphere, not only in the medical field. This will provide more benefits to the community in this pandemic position and even in the post-pandemic scenario across the country [28]. A sensor-based trash can is a helpful project, which aids us in maintaining cleanliness. A red switch is brought on the side of the hand. By touching the switch, the dustpan will be opened. As soon as the sponge is finished, as soon as the given time is complete, the dustpan will close.

9.1. Enhanced Radiation Detection Technologies

Escalating threats from malicious use of worldwide nuclear material have driven fear into world governments since the attack on the World Trade Center towers. In response to this post 9/11 threat both international and national policies have been exclusive between developing countries and developed countries. This includes additional protocols by all member states of the International Atomic Energy Agency (IAEA) and new Homeland Security (HS) regulations in the U.S. The intent of all partners includes enhancing monitoring abilities externally and internally for their nuclear facilities and for the world. Homeland Security has additionally initiated a program to install 1,000 Radiation Portal Monitors at ports-of-entry, and issued a pilot program policy opportunity to install varying radiation detection devices in various systems including, Railpads, Toplifts, and cargo containers. Trouble-free radiation detection devices are also being purchased to form a rapid response to copiously populated venues in the event of an emergency, in order to guard the citizenry from radiological dispersion devises (RDD) [23]. The bin's radiation monitoring system is a response to the HS initiative and thus was created to the maximum extent presently possible given the constraints of the contract and technical ability of the currently available components.

9.2. Smart Monitoring and Alert System

The cloud-based IoT is an ACCS project that enables secure data transfer. The continuous monitoring of a hospital is taking into account the waste management and ensures the safety of patients and people from the COVID disease. This smart dustbin sense on health and takes place to alert the operation team to dispose of waste with radiation [28]. The hospital is not just for the treatment of COVID, and normal patients visit hospitals daily. Some are sick and some for treatment. In the hospital, major work is conducted by doctors, and others must care for their health. So, with this project, we can provide a safe environment by monitoring waste equipment and alerting both the operation system and people. The waste management operation system consists of disposing of waste regularly and virus strain. At a particular time, W0 released waste is infected with a virus/bacteria. The device waste equipment takes place W1, W2, W3. Moreover, hate equipment was infected by that virus/bacteria, The disposal team disposes of that waste from the hospital to an open area, and here, the remaining WM bins must continue with charge monitoring, enforce and dispose of equipment waste.

Smart Monitoring and Alert System with IOT

The waste control has consisted of yellow color hazardous waste bins. Here, the monitoring device must sense Doctor D1, D2, D3, Dn with a waste control formation system that is under the tracks. On the continuous monitoring, if the common doctors cross their wise, it will alert both the control formation system and doctors. After reaching their warning, the control formation system is well known alert the other wise works team moving with the waste team WM that has an advance IOT formation connected with the Waste Equipment WE, as a resulting taking the alert action [1]. There is a number of waste generated in recent days due to the treatment. It is challenging for these hospital waste must be infective, hazardous chemicals. These are disposed of call to action with these nearly exposed sides.

10. Conclusion

In this work, we have proposed an innovative medical waste identification system imbibe with a radiation detector. This system consists of a dustbin where different categories of waste are being disposed by a hospital. A radiation detector with the dustbin is used to detect and locate the position of the radiation source that was inadvertently disposed of in the dustbin. When a radioactive object is found in the dustbin, a buzzer alarms. Safe distance is maintained from the radioactive object using an ultrasonic sensor. The aim of this idea is to procure safety to the environment and staff in the hospital.

Work was featured in the field of medical diagnosis, medical treatments in hospitals, and even in radiotherapy, where radioactive objects are being handled. Nowadays, with advancement in technology, usage of radioactive materials has been gradually increased in health sectors. Though radioactive materials provided immense benefit in the field of health care but its usage possess a potential threat to the environment and health of the staff. In order to avoid any kind of misplacement of a radioactive object, it is required to inspect the waste properly so that, it should be disposed in an appropriate way. Biohazards waste concept is for those materials which includes a specimen, blood, body fluid infected, etc. If these types of waste are not disposed properly, it can cause an infection to other patients or health staff too. Other waste categories include general hazardous waste, recycle waste, and E-waste. Open landfill disposal is one of the possible ways of disposing of waste but waste segregation is not possible. Burning the waste results in the release of toxic fumes which is not safe for the environment.

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